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Investigation of the properties of quantum-dimensional semiconductor particles A^3B^5 by scanning probe microscopy, obtained by liquid chemical etching

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Nanoparticles of semiconductor monocrystals A^3B^5 (GaAs) were ground mechanically submicron dispersion in a planetary ball mill by liquid chemical etching in a peroxide-ammonia solution were obtained. Dimensions of nanoparticles were in the range from 1 to 5 nm with a predominant size of 2-3 nm. Particle sizes were determined by Z-saizer-nano granulometric analysis and atomic force microscopy (AFM). Current-volt characteristics (CVC) were studied by the method of scanning tunneling microscopy (STM). The results correspond to the theory of field emission in the range of electric field strengths roughly of 1 V/nm. The obtained particles of gallium arsenide can be used for the production of semiconductor colloidal quantum dots, promising in optical sensors.

Gallium arsenide has a rather narrow width of the forbidden band, high mobility of electrons and holes. These properties are of interest for the wide use of this substance in optoelectronics.

The GaAs single crystal was milled on a planetary ball mill of the PULVERISETTE type (Fritsch - Germany). The particle size resulting from milling is 250-1300 nm. Liquid chemical etching of the nanopowder was carried out by a peroxide-ammonia mixture, which is "classical" for polishing the surface of gallium arsenide semiconductor films and its analogs in industry by adjusting the concentration of etchants [1].

The obtained GaAs samples were placed on a glass substrate with a layer of indium-tin oxide. The investigations were carried out using atomic force microscopy (AFM) and scanning tunneling microscopy (STM) using the NANOEDUCATOR-2 microscope.

The tunneled CV characteristics of the investigated objects were obtained by the STM method. In the course of the studies, tunneling CVCs with a negative bias potential on the substrate relative to the probe were examined and analyzed (Fig. 1). In this case, electrons tunnel from the ITO electrode through the discrete levels of the quantum-dimensional object to the probe of the tunneling microscope. The experimental results show their correspondence to the theory of field emission in the range of electric field strengths roughly of 1 V/nm.

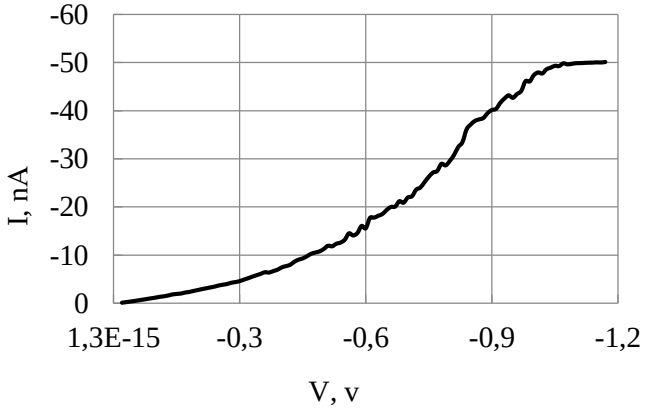

Figure 1. CVC of the GaAs quantum dots.

In the course of the experiment, the optimal conditions for chemical etching of the nanopowder (GaAs) with a peroxide-ammonia mixture for obtaining the desired nanoparticles were chosen. The results of the investigation of the surface morphology and I-V characteristics of the obtained particles by scanning probe microscopy method are obtained. The synthesized material can be used as a basis. This approach can be used to obtain semiconductor colloidal quantum dots (using an additional coating by their cladding), promising in optical sensors [2,3].

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